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RAIL GRINDING GAUGE MANUAL

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MANUEL DU CALIBRE DE MEULAGE DE RAIL

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ABSTRACT

This manual describes the purpose, usage, and usefulness of the rail grinding gauge. The gauge is of sturdy design and consists of four interchangeable templates mounted to a bar. It is also available in digital form and could be easily installed on the Light-Slice, Machine Vision System or other electro-optical systems that measure the shape of the rail head profiles in track. The gauge ensures that the profile of the ground rail has the desired shape and is correctly oriented with respect to the track level. It also can be used in the selection of grinding patterns for the grinding of new, corrugated, or mushroomed rail and in preventative grinding. Grinding of the rails into the desired profiles prescribed by the gauge, particularly in the lubricated territories, protects the rail from early development of surface defects, while allowing an appreciable portion of the wheelsets to steer through curves by a rolling radii difference. The economic value of these two features is substantial.

RÉSUMÉ

Le manuel présente les fonctions, le mode d'utilisation et l'utilité du calibre de meulage du rail. Le calibre, de construction solide, comprend quatre gabarits permutables montés sur une barre. Il est également disponible sous forme numérique et peut être facilement monter sur les machines Ligth-Slice, Machine Vision System et autres appareils électro-optiques que mesure le profil de champignons du rail en voie. Le calibre permet de s'assurer que le rail a bien le profil voulu et l'orientation correcte pour sa hauteur en voie. Il peut également servir tant à la sélection de formes de meulage pour les rails neufs et pour les rails à usure ondulatoire ou à champignonage qu'au meulage préventif. Le meulage selon un profil choisi grâce au calibre, particulièrement sur les voies dotées de graisseurs, protège les rails contre l'apparition précoce de défauts superficiels et permet le contact avec une large surface des roues dans les courbes, en raison de la différence de rayon des roues. Des réductions substantielles de coûts résultent de ces deux fonctions.

CONTENTS

	Page
ABSTRACT/RÉSUMÉ	1
LIST OF ILLUSTRATIONS	ii
LIST OF TABLES	iii
1.0 INTRODUCTION	1
2.0 DESCRIPTION OF THE GRINDING GAUGE	2
3.0 USAGE OF THE GRINDING STATE	3
3.1 Corrective Grinding	3
3.1.1 Selection of templates	3
3.1.2 Selection of grinding patterns	4
3.2 Grinding of New Rails	4
3.3 Preventive Grinding	5
4.0 CONCLUDING REMARKS	5
5.0 REFERENCE	6
DOCUMENTATION PAGE	

LIST OF ILLUSTRATIONS

Figure	Page
1 The worn rail profile, as an envelope to all wheel profiles that pass over that rail.	11
2 The rail grinding gauge.	
3 (a) Track gauge measurment. (b) PTP measurement.	13
4 (a) An example of a correctly ground rail. (b) A low rail in mild curve that needs additional grinding at the field side.	14
5 Required metal removal to change new 136 RE profile to desired profiles in tangent and curved track.	15
6 Required metal removal to change new 136 CN profile to desired profiles in tangent and curved track.	16

LIST OF TABLES

Table		Page
1	"Imperial" selection guide for rail grinding templates.	7
2	"Metric" selection guide for rail grinding templates.	8
3	Comparison of railhead radii for different sections of new rails.	9
4	Summary of initial rail grinding requirements for 132 RE, 136 RE, and 136 CN railhead profiles.	10

RAIL GRINDING GAUGE MANUAL

1.0 INTRODUCTION

Most people involved in rail grinding will agree that the profile to which the rail is ground can significantly affect, for better or worse, the future behaviour and performance of rail surfaces. Several independent studies were carried out to determine what profiles extend rail life the most. Many of these studies searched for the desired grinding patterns for tangent track and mild and sharp curves, but rarely for the desired geometry of rail profiles.

A recent NRC technical report (Kalousek 1987) defined the criteria on which the desirability of rail profile geometry should be based as follows:

- a) to minimize the frequency of contact for each element of material at the rail surface,
- b) to minimize contact stresses, and
- c) to improve the steering of freight car trucks.

The first two conditions protect the rail material. To minimize the frequency of contact requires that, after the rail is ground, the wear band left by the first loaded train is reasonably wide. Some of the wheels will then contact the rail at the gauge corner, some at the centre, and some at the field side of the rail. If this band is too narrow, the material beneath it is contacted by almost all the wheels, which leads to early development of flakes at the centre of the railhead. By allowing contact at the gauge corner of the high rail and the field side of the low rail, the rolling radii difference on a certain percentage of wheelsets is maximized. These wheelsets can negotiate curves without flange contact, thereby contributing to fuel savings on locomotives.

The contact stresses can be minimized most effectively if the composite envelope of all the wheels, consisting of individual wheel profiles, and their lateral position with respect to the rail is taken into account. It has been well documented that a population of wheelsets in a train is spread (i.e., statistically distributed) with respect to the angle of attack and lateral displacement. The mean value for the wheelset lateral displacement distribution can be measured in the tangent track at its centre, but in curves it is displaced towards the high rail. In addition, the wheel profiles vary over a wide range depending on their state of wear. Therefore the rail, in an extreme case, can be contacted at the gauge corner by the new or partly worn wheel and at the field side by the badly worn wheel (see Fig. 1). Of course, the rail is also contacted across its wear band by all other worn wheelsets at different angles of attack and lateral displacements. A profile of worn rail is, therefore, an envelope to all the wheel profiles.

As the wheelset travels over the right- and left-hand curves and some tangent track in between, it sees a mixture of new and worn rails. Rails in different sections of track touch the wheels at different locations. Hence any wheel is contacted by an envelope of rails which governs the worn shape of wheels. Therefore, there are two sets of envelopes, one of wheels and one of rails, to consider. If these sets conform to each other, contact stresses, wear, and plastic flow can be minimized.

All this may seem to be complicated, but it is helpful in understanding how the rail grinding gauge works. The profiles on the templates that the gauge uses are essentially an envelope of new (CN Heuman and AAR) and worn wheels, as seen by the rails located in tangent, mild and sharp curves. If the rail is ground exactly to the template profiles, the best possible compromise between the requirements of material protection and steering requirements is reached.

If the rail is ground 0.2 mm (0.008in) deeper than the templates at the gauge corner of the high and field side of the low rails, then the material is overprotected with respect to the initiation of contact fatigue cracks, because fewer wheelsets contact the rails at these locations. On the other hand, if an insufficient amount of material is removed at these locations, then more wheelsets negotiate the curve by a rolling radii difference. This may further enhance fuel saving, but only at the expense of the early development of shelly spots, flakes, and corrugations in the curves.

2.0 DESCRIPTION OF THE GRINDING GAUGE

The gauge consists of a collapsible bar with a handle, to aid in storage and transportation, and four templates (a template each for (i) tangent track, (ii) high rail in mild curves, (iii) high rail in sharp curves, and (iv) low rails in mild and sharp curves). Each template is also provided with a flip latch, which is flipped to the down position to measure the track gauge. The tangent track and low rail templates are to be attached to the left side of the gauge bar and the high rail templates to the right side. The unused templates are attached to the bar as shown in Figure 2.

The right side of the gauge has a scale installed above the template. The alignment of the right-hand high rail templates with zero on this scale gives the standard gauge; i.e., the distance between the flip latches in the down position is exactly 1435 mm (56 1/2in). The right-hand template can be moved to accommodate changes in the track gauge or profile to profile (PTP) gauge. The scale above the right-hand template shows how wide or narrow the track or PTP gauge is (e.g., see Fig. 3a).

However, the PTP gauge is more important because this is the gauge that determines the contact points between the wheelset and pair of rails. Because of plastic flow or gauge face wear, the PTP gauge can be either narrower or wider than the track gauge. Figure 3b illustrates the change in the gauge when the template becomes aligned with the rail profile. In the particular example shown in Figures 3a and 3b, the plastic flow, on only one rail, narrows the PTP gauge by 2 mm (5/64in).

When measuring the PTP gauge, templates on both rails must be aligned to the rail profiles and the flip latch should be in the up position, especially on badly worn rails.

3.0 USAGE OF THE GRINDING GAUGE

The primary purpose of the rail grinding gauge is to assure a correct selection of grinding profiles and to check the profile of ground rails. This process should be used in corrective grinding of mushroomed (i.e., with plastic flow) and (or) corrugated rails, in grinding of the new rails, and in preventive grinding.

3.1 Corrective Grinding

3.1.1. Selection of templates

Prior to any decision as to what template should be used, one must establish the PTP gauge. In curves the PTP gauge is obtained as the best fit of template profiles to the rail profiles. However, since only one template is provided for tangent track, the PTP gauge has to be established in two steps. First, the track gauge is measured, followed by the adjustments for the plastic flow or wear for both rails. Again, since there is only one tangent track template, it has to be applied to left and right rails separately, simply by turning the measuring bar around. As shown in the example of Figure 3, the track gauge is $1435 - 5.5 = 1429.5$ mm ($56 \frac{9}{32}$ in). The plastic flow shifts the profile of the right rail on the gauge by an additional 2 mm ($\approx 3/32$ in), as the comparison of Figures 3a and 3b indicates. Assuming the plastic flow indicated on the gauge for the left rail is 2.5 mm ($\approx 3/32$ in), the PTP gauge is $1429.5 - (2 + 2.5) = 1425$ mm ($56 \frac{3}{32}$ in). Thus, in this example, the PTP gauge is 4.5 mm ($3/16$ in) narrower than the track gauge, which itself is narrow by 5.5 mm ($7/32$ in). In total, the PTP gauge is 10 mm ($13/32$ in) narrower with respect to the standard track gauge.

Once the PTP gauge is established, the templates may have to be changed. Recalling the discussion on wheel and rail wear envelopes it should be obvious that, if the PTP gauge in tangent track is narrower by 5 mm ($3/16$ in) or more, both rails will wear or initiate contact fatigue cracks in the same fashion as the high rail in mild curve. Thus, both rails should be ground to conform to the mild curve high rail template. On the other hand, if the PTP gauge in tangent track is, say, more than 8 mm ($5/16$ in) wider than the standard track gauge, then both rails should be ground to conform to the low rail template, with special attention to its field side portion.

The selection of templates in curves should be straightforward. As a general rule, a 3° curve is used to separate mild and sharp curves. However, depending on other track conditions, namely the PTP gauge and superelevation, some curves larger than 3° may behave as mild curves and vice versa. Also, in very sharp curves or in curves with significant gauge widening, the field side of the low rail should be ground more than the low rail template indicates. Tables 1 and 2 suggest the template selection as a function of the measured PTP gauge.

3.2.1 Selection of grinding patterns

The selection of grinding stone patterns to achieve the conformity between the ground rail and template is rather simple. The contact angle at which the template touches the rail indicates the mean angle around which the grinding stones should be distributed. (It should be noted that the angles marked on all templates are not compensated for cant.) The required depth of cut at this angle is given by the maximum gap found along the template and rail profiles. The size of the gap can be easily established with the help of filler gauges. Figure 4a shows an example of perfectly ground high rail in a mild curve. The ground rail profile conforms very closely to the profile on the template. Figure 4b shows the low rail, of the same curve, that requires additional grinding at the field side.

Since most grinding trains have at least a dozen preset grinding patterns, usually stored in the memory of an on-board computer and available at the touch of button, selecting the most appropriate pattern that removes more metal from a particular location should not be too difficult. However, if each of the available grinding patterns fails to take metal from the appropriate location, a new grinding pattern should be designed. Although the rail grinding gauge could be rather useful in such processes, the actual design of new grinding patterns requires great expertise, the discussion of which is beyond the scope of this manual.

3.2 Gringing Of New Rails

The new rail has to be ground for several reasons. Removal of scale and the decarburized layer was the usual reason given in the past. However, grinding the new rail into a worn and, therefore, correct profile can prevent early initiation of contact fatigue cracks. It has been suggested that the rail could be rolled into the desired railhead profiles in the steel mill to avoid initial grinding. Unfortunately, these profiles, as mentioned previously, are specific to track location and it would be difficult, if not impractical, to control the positioning and correct orientation of the rails with such profiles, during rail welding and installation.

On the other hand, the grinding of new rail should not be as difficult as that of the mushroomed rail because the head profile geometry of the new rail is known, but, as Table 3 shows, each type of rail has a different railhead profile geometry. Nevertheless, it is easy to establish the amount of material to be removed for each type of rail. This is shown in Figures 5 and 6 for the 136 RE and 136 CN rails canted 1:20. A 1:40 cant would require deeper and shallower cuts at the gauge corner of the high rail and the field side of the low rail, respectively.

Table 4 shows the comparison of the maximum depth of cut and rail cross sectional area to be removed by grinding for several types of rails at different locations. An examination of this table reveals that the gauge corner of high 136 RE rail requires the largest cut, while the 132 RE rail requires a minimum cut when located in tangent track. To compare how much metal has to be removed for several types of rail, an

initial grind index was calculated. It was obtained as the sum of cross-sectional areas for the rail in the mild and sharp curves. The initial grind index marked "all" also includes tangent track.

3.3 Preventive Grinding

Once the new or old rail is reclaimed and is ground free of cracks and into a shape conformal with the rail grinding gauge, the rail surface should be maintained free of cracks, flakes, shelly spots and corrugations by a preventive rail grinding program. This program requires that a single pass of the grinding train remove no more than 0.05 mm (0.002in) of material each 5, 10, and 15 million gross tons (MGT) of traffic on sharp ($>3^\circ$) and mild ($<3^\circ$) curve tracks and tangent track, respectively.

This can easily be achieved by dividing any subdivision into territories of track that each contain one section of sharp curves, two sections of mild curves, and three sections of tangent track. The grinding train passes over the territory after 5 MGT of traffic and grinds all the sharp curves, half of the mild curves, and a third of tangent track sections, so that all the mild curves and tangent track are ground once for every 10 and 15 MGT, respectively.

A stone grinding pattern can easily be designed for tangent and curved tracks, which should maintain the rail profiles conformal to the rail grinding gauge. However, because of the plastic flow of rail steel into the gauge corner of the high rail and the field side of the low rail, it is recommended that the depth of material removed at these locations is doubled. When softer grades of rail material are used (i.e., plain carbon rail in mild and medium premium rail in sharp curves), even deeper cuts may be required at these locations. Ideally, it is desirable to have a small gap (0.002 to 0.005in) between the rail and the rail grinding gauge template at the gauge corner of the high rail and the field side of the low rail, in curves just after the grinding, and no gap at these locations just before the grinding. Again, a successful design of preventive stone patterns for a particular type of grinding equipment could be best achieved by experimentation and experience.

4.0 CONCLUDING REMARKS

- (i) Usage of the rail grinding gauge eliminates "overprofiling" or "underprofiling" (either too much or too little material removed from the gauge corner of the high rail and the field side of the low rail). The template profiles coincide with the actual natural rail and wheel wear patterns. Thus, the rail in lubricated territories, ground to these profiles, has the maximum material protection to surface defects. It also allows for an appreciable portion of wheelsets to steer through curves by a rolling radii difference. The economic value of these two features is substantial.
- (ii) A close adherence for desired shape of the rail profiles may permit an extension of the basic preventive rail grinding period from 5 MGT up to 8 MGT of traffic (i.e., 8 MGT for sharp, 16 MGT for mild curves, and 24 MGT for tangent track).

However, this extension in the grinding period should be approached with caution since other factors, related to the type of rolling stock, track profile, and the type and availability of grinding equipment, affect the economy and economic outcome of maintenance grinding.

- iii) The rail grinding gauge was designed on a CAD (computer-aided design) system and is, therefore, available in a digital form. It can be easily installed on electro-optical rail profile measuring devices such as the Light Slice, Servo-Robot, and Machine Vision Systems.

5.0 REFERENCE

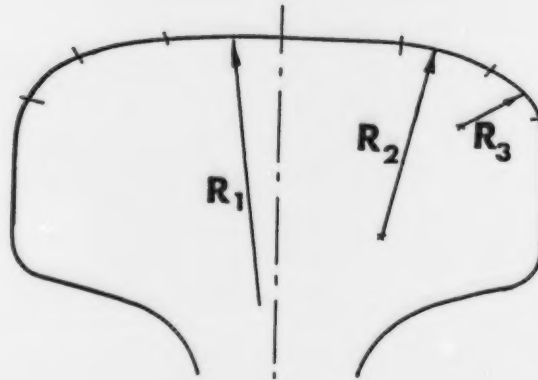
KALOUSEK, J. 1987. Wear and Contact Fatigue Model for Railway Rail. Division of Mechanical Engineering, National Research Council of Canada, Ottawa, Ont. Report No. TR-WE-50 (NRCC 27491).

Type of track	Measured PTP gauge	Template type			
		Tangent	High rail, mild curves	High rail, sharp curves	Low rail
Tangent	3/16in narrow to 5/16in wide	X (both rails)	X (both rails)	X (both rails)	X (both rails)
	3/16in narrow to 3/8in narrow				
	3/8in or more narrow				
	5/16in or more wide				
Mild curves (3° or less)	Standard gauge to 5/16in wide	X (low rail)	X X	X	X X (over profile by 0.008in at field side)
	5/16in or more wide				
	Standard gauge or narrower				
Sharp curves (more than 3°)	Standard gauge to 5/16in wide	X (low rail)		X X	X X (over profile by 0.010in at field side)
	5/16in or more wide				
	Standard gauge or narrower				

Table 1. "Imperial" selection guide for the rail grinding templates.

Type of track	Measured PTP gauge	Template type			
		Tangent	High rail, mild curves	High rail, sharp curves	Low rail
Tangent	5 mm narrow to 8 mm wide	X (both rails)	X (both rails)	X (both rails)	X (both rails)
	5 mm narrow to 10 mm narrow				
	10 mm or more narrow				
	8 mm or more wide				
Mild curves (3° or less)	Standard gauge to 8 mm wide	X (low rail)	X X	X	X X (over profile by 0.2 mm at field side)
	8 mm or more wide				
	Standard gauge or narrower				
Sharp curves (more than 3°)	Standard gauge to 8 mm wide	X (low rail)		X X	X X (over profile by 0.3 mm at field side)
	8 mm or more wide				
	Standard gauge or narrower				
				X (over profile by 0.2 mm at gauge side)	

Table 2. "Metric" selection guide for the rail grinding templates.



Section	R_1 (in)	R_2 (in)	R_3 (in)
115 RE	10	1 1/2	3/8
119 RE	14	1 1/2	9/16
132 RE	10	1 1/4	3/8
136 RE	14	1 1/4	9/16
136 CN	4	-	9/16

Table 3. Comparison of railhead radii for different sections of new rails.

RAIL TYPE	HIGH RAIL, SHARP CURVE		HIGH RAIL, MILD CURVE		LOW RAIL, SHARP & MILD		TANGENT TRACK		INITIAL GRIND INDEX	
	DEPTH (in)	AREA (in ²)	DEPTH (in)	AREA (in ²)	DEPTH (in)	AREA (in ²)	DEPTH (in)	AREA (in ²)	CURVES (in ²)	ALL (in ²)
132 RE	0.053G	0.045	0.028G	0.019	0.057F	0.051	0.010G	0.004	0.115	0.119
136 RE	0.075G	0.057	0.053G	0.033	0.039F	0.042	0.029G	0.014	0.132	0.146
136 CN	0.046G	0.040	0.024G	0.015	0.046C	0.038	0.035C	0.038	0.093	0.131

Table 4. Summary of initial rail grinding requirements for 132 RE, 136 RE, and 136 CN railhead profiles (G, gauge; F, field; C, centre).

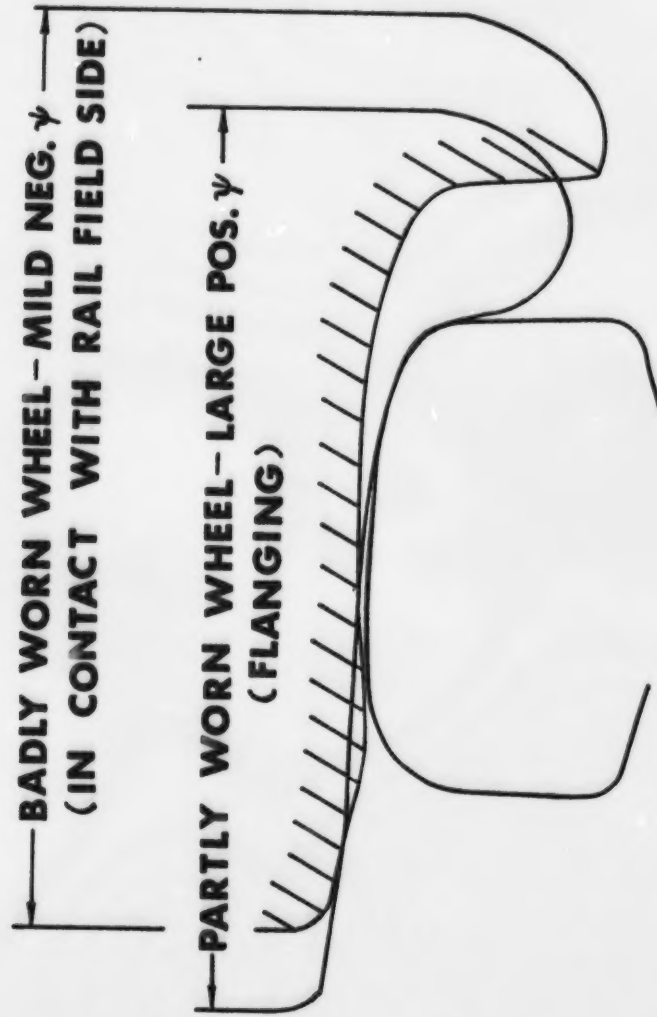


Figure 1. The worn rail profile, as an envelope to all wheel profiles that pass over that rail (ψ is the angle of attack).

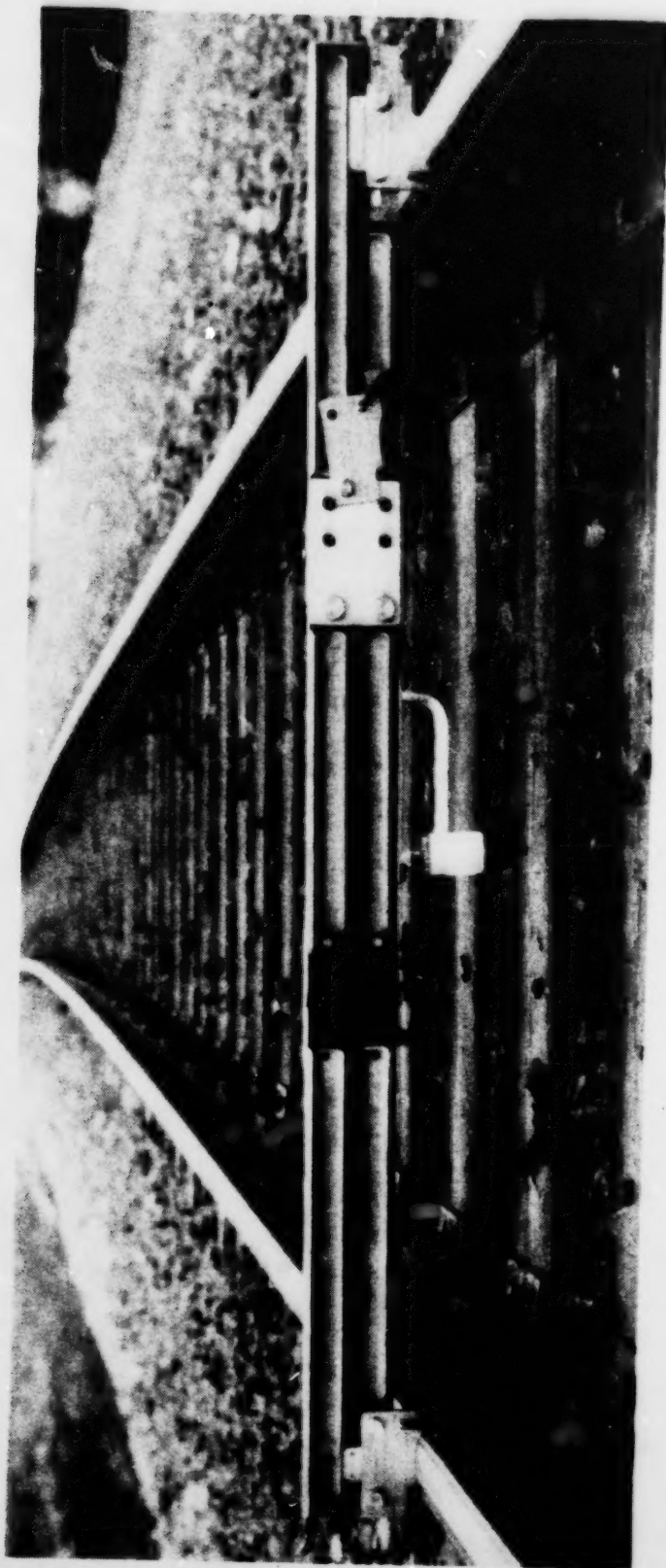


Figure 2. The rail grinding gauge.

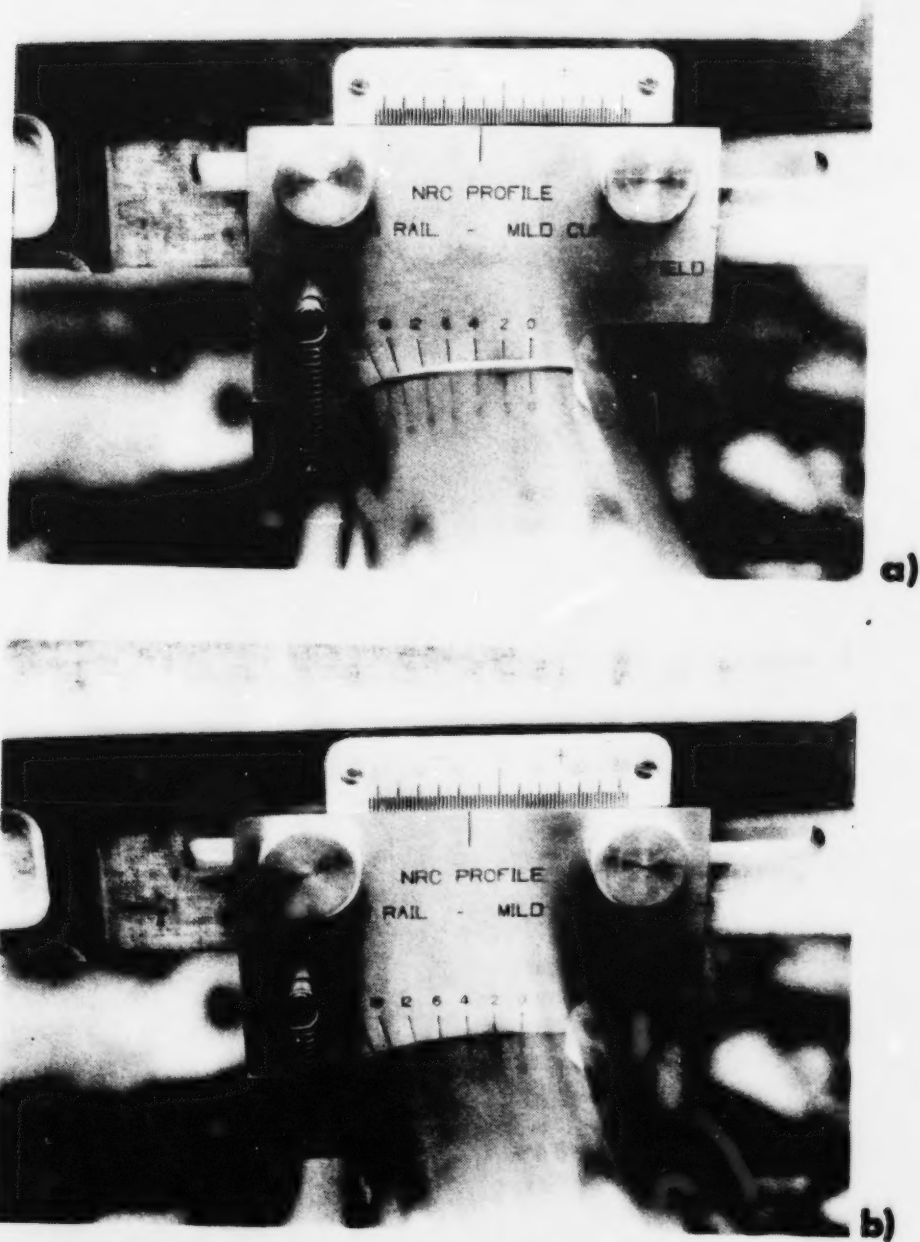


Figure 3. (a) Track gauge measurement.
(b) PTP measurement. In the case of the worn high rail, the flip latch must be in the "up" position.

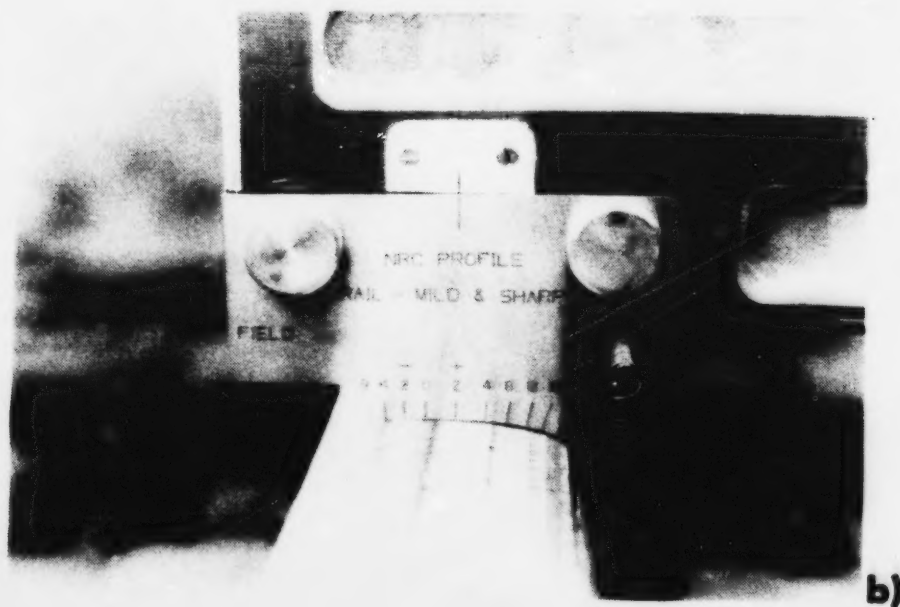


Figure 4. (a) An example of a correctly ground rail.
(b) A low rail in mild curve that needs additional grinding at the field side.

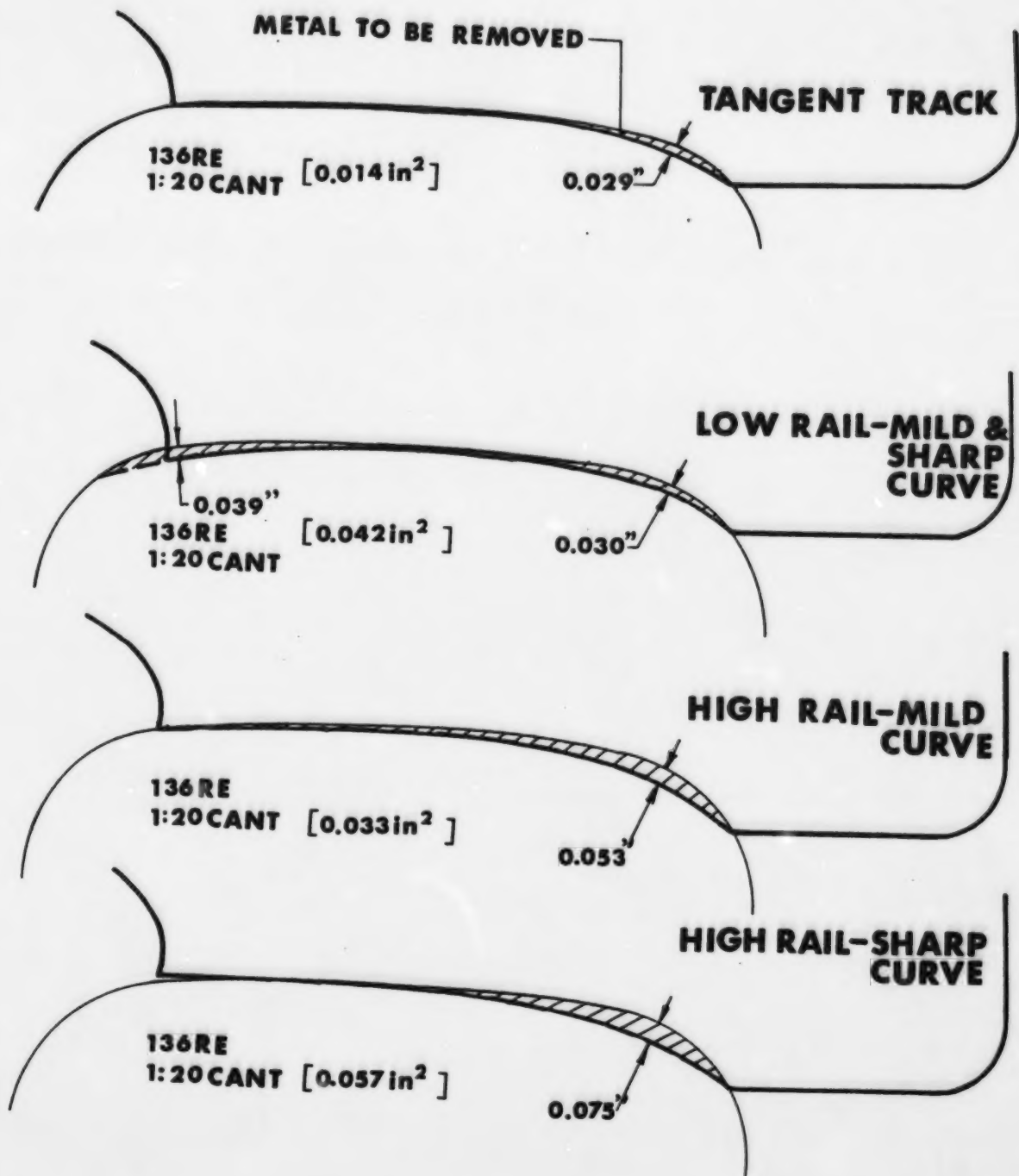


Figure 5. Required metal removal to change new 136 RE profiles to desired profiles in tangent and curved track (the size of hatched area is shown in brackets).

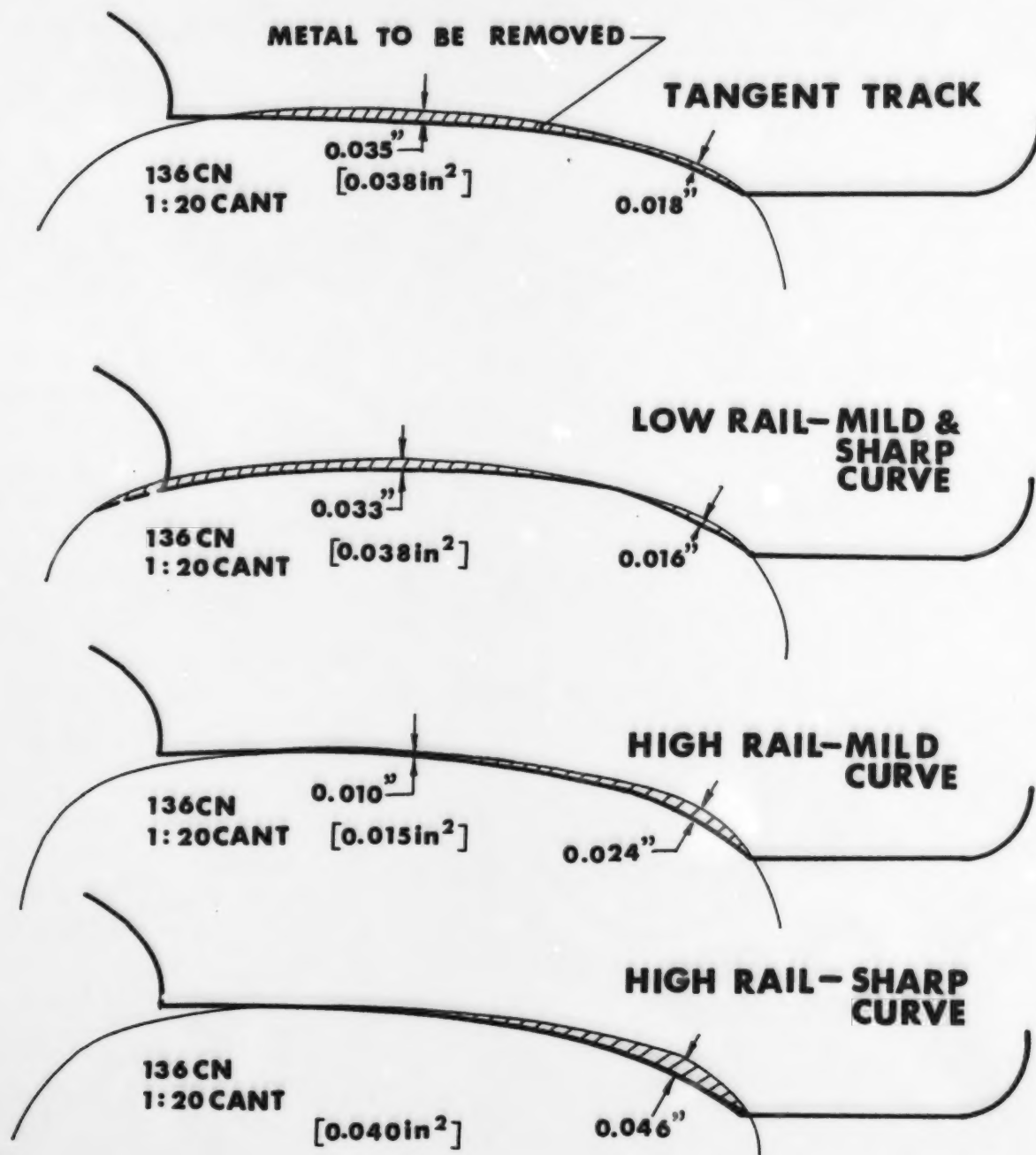


Figure 6. Required metal removal to change new 136 CN profile to desired profiles in tangent and curved track (the size of hatched area is shown in brackets).

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